(49521)59234

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
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Richard BAJAN) Group Art Unit: 1762
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Serial No.: 10/642,368) Examiner: Katherine A. Bareford
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Filed: August 15, 2003) Confirmation No. 2534
)
For: **METHOD FOR APPLYING METALLURGICAL COATINGS TO GAS TURBINE COMPONENTS**)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF RICHARD BAJAN PURSUANT TO 37 C.F.R. §1.132

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited in first class mail addressed to: Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date indicated below.

Date: November 21, 2005

Scott D. Wofsy

I, Richard Bajan, declare as follows:

1. I am the inventor of the above-referenced application and have over twenty-five years of experience in the field of thermal spray coatings for turbomachinery. I am presently a Thermal Spray Coating Process Engineer at Goodrich Corporation, Turbine Component Services in Hodges, South Carolina. Goodrich Corporation has employed me in this capacity since January of 1997. In my current position I design, install and demonstrate production capability of robotic HVOF, plasma and arc wire thermal spray processes, including precoating surface preparation, and post coating shot peen and vibratory finishing processes. I hold an AAS degree in Mechanical Technology from State University of New York at Farmingdale.

2. The subject application is directed to a method of applying a protective metallurgical coating to a gas turbine component by a process known as high velocity oxygen fuel spray (HVOF). In the HVOF process, a metal powder is melted and directed at a substrate at high particle velocity. This produces a densely deposited coating that is useful in operating environments that are thermally and chemically hostile, such as the environment within a gas turbine engine. In order to apply a metallic coating by HVOF that will properly adhere to a substrate at elevated temperatures and under high stresses, it is necessary to properly prepare the surface of the substrate prior to deposition of the coating.

3. Traditionally, the surface of a substrate is roughened to improve adhesion of a coating layer applied by the HVOF process. It is believed that the roughened surface is required to provide a mechanical adhesion component for the attachment of the metallic layer, because the relatively low application temperature of an HVOF coating typically creates a relatively weak metallurgical bond. The surface preparation of a substrate for application of a metallic

coating by HVOF is generally accomplished by grit blasting. However, it has been found that grit blasting can embed media in the substrate surface. This can adversely affect the interface between the HVOF coating and the substrate, and may contribute to delamination of the coating.

4. The current invention addresses the problems associated with the use of grit blasting alone to roughen the surface of a substrate prior to application of an HVOF coating. In particular, the subject application discloses, among other things, a method that includes the step of directing a water jet having a pressure of about between 45,000 to 65,000 psi against the surface of the substrate while traversing the surface at a sweep rate of about between 25 to 100 inches per minute and at a stand-off distance of about between .375 to 1.00 inches, to modify the surface morphology of the substrate in such a manner so as to expose the underlying grain structure of the superalloy. The method further includes the step of depositing a metallurgical coating on the modified surface of the substrate by high velocity oxygen fuel spray (HVOF).

5. As a result of the high pressure water jet preparation step of the subject invention, the modified surface of the substrate has a microscopic roughness characteristic (i.e., "super micro-roughness") that advantageously promotes the formation of a bond between the substrate and the metallurgical coating that is sufficient in strength to support the deposition of a coating having a thickness in excess of about 0.500 inches. The coating thickness that results from the super micro-roughened surface is completely unexpected.

6. When the surface morphology of a substrate prepared by the claimed high-pressure water jet treatment is evaluated using normal industry standard inspection techniques, it appears flat and planar in nature (see Fig. 9 of the subject application), as compared to a grit blasted substrate surface (see Fig. 8 of the subject application). Furthermore, when the surface of

a substrate prepared by the claimed water jet treatment is inspected using a contact stylus type profilometer instrument and 3-D interferometric surface analysis, the surface roughness is not as high as the surface roughness of a grit blasted surface. Based on such observations, conventional industry wisdom would have lead to the conclusion that coating bond strength and overall coating quality would be better when using the grit blasted surface as opposed to the water jet prepared surface, and the water jet prepared substrate would have thus been discarded before HVOF coating.

7. The super-micro roughened surface morphology that promotes the unexpected results exhibited by the claimed high pressure water jet surface preparation was only detected by the applicant viewing the surface morphology of the substrate at 5000x magnification. In particular, Fig. 10 of the subject application shows the surface morphology of a grit blasted surface at 5000x magnification. That surface appears predominantly flat and planar, providing a relatively low volume of surface area for bonding with the HVOF coating. In contrast, Fig. 11 of the subject application shows the surface morphology of the high-pressure water jet prepared surface at 5000x magnification. That surface exhibits a vastly increased amount of surface area for bonding with the HVOF coating. The resulting super-micro roughened surface morphology is completely unexpected and contrary to conventional industry beliefs.

8. The subject application discloses an example in which the claimed method was utilized to achieve a metallurgical coating having a thickness in excess of 0.500 inches. In this instance, the surface of the substrate was initially grit blasted with 36 mesh aluminum oxides at 80 psi, and then water jet treated at 55,000 psi, at a sweep rate of 75 inches per minute and at a stand-off distance of 0.625 inches. The substrate was then coated using PAC IN 738 HV

powdered superalloy. A total of 673 spray cycles occurred, resulting in approximately 0.592 inches of total coating. This result was completely unexpected.

9. I have reviewed the Office Action dated June 21, 2005, issued in connection with the subject application. As I understand the Office Action, the Patent Examiner has rejected certain claims of the application as being obvious in view of documents that include the following: an article by James K. Knapp and Thomas A Taylor entitled "Waterjet roughened surface analysis and bond strength" (Surface and Coatings Tech. 86-87 (1996) 22-27)(Knapp et al.); U.S. Patent No. 5,512,318 to Raghavan et al.; U.S. Patent No. 5,956,845 to Arnold et al.; U.S. Patent No. 6,607,611 to Dariola; European Patent No. 750 054 A1 to Taylor; and WO 02/40745 to Dietrich et al.

10. I disagree with these claim rejections and the Examiner's conclusions.

11. The present invention illustrates that the claimed operational parameters for high pressure water jet preparation of a superalloy substrate result in a surface morphology that promotes the formation of a mechanical bond between the substrate and the metallurgical coating that is far superior than previously know in the art. Indeed, as set forth below, there is nothing in the prior art references cited by the Examiner in the Office Action that suggests either alone or in combination, in whole or in part, a surface treatment method for producing a surface morphology that promotes a bond sufficient in strength to support the deposition of an HVOF coating having a thickness in excess of about 0.500 inches. The specification of the subject application describes an example of a water jet method that produces a surface morphology that promotes a bond having sufficient strength to support an Inconel 738 HVOF applied coating having a thickness in excess of 0.500 inches.

12. The Knapp article reports plasma sprayed MCrAlY coatings with a thickness in the range of 0.13 mm to 0.38 mm (.005 in. to .015 in), which exhibited a bond strength of about 70-75 MPa (10-12 ksi). In contrast, the claimed method produced coatings that were nearly forty (40) times thicker than the coatings described in the Knapp article, and enabled the preparation of tensile specimens that exhibited a coating tensile bond strength that averaged 95 ksi, which is nearly nine (9) times the bond strength reported in the Knapp article.

13. The Raghavan patent describes a method of roughening the surface of a substrate prior to application of metallurgical using a high-pressure water jet. However, Raghavan does not disclose the combination of operational parameters that I found are necessary to produce a surface morphology on a superalloy substrate that promotes a bond sufficient in strength to support the deposition of an HVOF coating having a thickness in excess of about 0.500 inches.

14. The European Patent to Taylor discloses modification of a substrate surface by a high-pressure water jet prior to thermal spray coating, but fails to disclose whether the modified surface has a microscopic roughness characteristic that promotes a bond sufficient in strength to support deposition of an HVOF coating having a thickness in excess of 0.500 inches.

15. U.S. Patent No. 5,956,845 to Arnold et al. discloses an HVOF spray process for treating metal components, wherein the coating is built-up to a thickness that is effective to obtain desired finished dimensions after performing a hot isostatic pressing treatment. In one example, a test piece was prepared by building up coating material to a thickness of approximately .02 inches. (See col. 12, lns. 21-22). Arnold et al. do not disclose or suggest modifying the surface morphology of the components in a manner that promotes a bond

sufficient in strength to support deposition of an HVOF coating having a thickness in excess of 0.500 inches.

16. U.S. Patent No. 6,607,611 to Dariola discloses a method of depositing a MCrAlX bond coat layer on a substrate, wherein the bond coat layer is preferably from about 0.0005 to about 0.005 inches thick, and most preferably about 0.002 inches thick. Dariola does not disclose or suggest modifying the surface morphology of a substrate in a manner that promotes a bond sufficient in strength to support deposition of an HVOF coating having a thickness in excess of 0.500 inches.

17. WO 02/40745 to Dietrich et al. disclose a method that involves the application of a bond promoting layer of MCrAlY on a substrate by low pressure plasma spray and then applying a ceramic layer of lanthanide pervoskite in a thickness of about 0.3 mm by means of atmospheric plasma spraying. Dietrich et al. do not disclose or suggest modifying the surface morphology of a substrate in a manner that promotes a bond sufficient in strength to support deposition of an HVOF coating having a thickness in excess of 0.500 inches.

18. I hereby further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that theses statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the subject application or any patent issued thereon.

Date: NOVEMBER 21, 2005

Richard Bajan

Richard Bajan